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# Augmented Duality: Overlapping a Metaverse with the Real World

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## ABSTRACT

The advent of metaverses provide exciting opportunities for augmented reality research. We have created a number of interactions between the metaverse Second Life and the real world. Camera phone image matching creates portals and triggers the metaverse to mimic real locations. Image processing, tracking, projection and 3D video sprites create varied possibilities for people and avatars to have presence in each others worlds.

We argue that these multiform contacts and overlaps between multiple points in the real world and an extensive and distinct metaverse constitute a new class of augmented reality interaction. Such a system of multiple parallel social existences may point to a mass social networking phenomenon built on the overlapping of a metaverse with the real world which we call Augmented Duality.

## Categories and Subject Descriptors

I.3.6 [Computing Methodologies]: Computer Graphics, Methodologies and Techniques, Interaction Techniques.

**General Terms** Design. **Keywords** Metaverses, Mobile Phones, Augmented Reality, Second Life, social networking.

## 1. INTRODUCTION

Augmented Reality is an important digital interaction concept with an ever increasing array of forms and applications. The advent of metaverses such as Second Life provide exciting opportunities for Augmented Reality research. A metaverse is an extensive 3D networked virtual world capable of supporting a large number of people simultaneously for social interaction.

In this paper we prefer to use the term “metaverse” coined by Stephenson in the novel Snow Crash [1] rather than the acronyms MMOG or just MMO standing for “Massively Multiplayer Online Game”. This is partly because we wish to stress the use of these systems for general social interaction and collaboration which go well beyond their initial use for ludic (playful) applications. Also the concept of metaverse implies the interaction of real people with the virtual environments and agents including avatars with increasing levels of immersion and presence which we see as the principle frontier of innovation whereas MMOG's as originally conceived are principally virtual occupying the virtual extreme of Milgram and Kishino's Continuum.

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Finally, the word metaverse (Meta -Universe) suggests the emergence of a new class of augmented social interaction which we term “augmented duality”.

## 1.1 Previous Work

Previous classical examples of augmented reality research [2] are numerous and varied in form. Generally however the virtual content of such systems is localised and of limited extent such as single objects, augmenting text and images or architectural models.. The advent of Metaverses presents a much more extensive virtual entity for augmentation with the real world. An innovative research project between Georgia Institute of Technology and Ludwig-Maximilians Universität Munich [3] has investigated adding an augmented reality component to Second Life by adapting the Second life client. Several applications were reported including a design prototype pit which can be viewed through head mounted displays. The project also describes “stages” which are areas in Second Life where avatars can go and then be present in a mixed reality display with a real environment. The applications seem to focus on augmented reality applications with virtual content added to a real world context whereas our work also implements augmented virtuality applications. Presence of people in Second Life is only on screens with overlays whereas our work includes the use of 3D video sprites to situate people in the world. Our work also includes the innovative use of camera phone image matching to augment Second life with real content and visa versa. We also highlight the augmentation of metaverses as the beginning of the emergence of a new class of augmented social interaction.

This work has been carried out within the context of the research project ‘Branded Spaces: Ubiquitous technologies and the design of places for meaningful human encounter’ which aims to explore the relationship between social encounter, technology and place. A methodology of ‘Research by Design’ has been adopted where design practice is used as a probe. The emphasis is less on requirements capture and more on the use of creativity to explore and invent the future through the creation of new forms of interactive digital media. In this work we have used a novel camera phone platform, image processing and the metaverse Second Life as tools. A series of three design interventions were carried out to transform interactions with the metaverse. Reflection on the possible significance of the interventions was then conducted.

## 1.2 Contribution

Firstly, we show three metaverse/real world augmentations:

- Novel use of camera phones to instantiate portals between the real world and a metaverse and to use

image matching of these images to trigger the metaverse to change physically and visually.

- Interaction between the real world and a metaverse through a symmetric two way *large screen* mixed reality boundary using image processing background subtraction and overlays. Both avatars and real people have the choice to see an augmented reality or augmented virtuality view through their respective screen boundaries.
- Interaction between the real world and a metaverse by instantiating real people in the metaverse by automated realtime extraction of video sprites which are given 3D positions in the metaverse corresponding to the tracked position of people in the real world.

We then use these effects to make the principal observation and contribution to theoretical debate that the sum of these technical metaverse/real world augmentations point to an emergent effect.

- Specifically, we suggest that as the use of metaverses becomes a mass participation phenomenon the use of augmentations with the real world will also grow. The creation of multiform contacts and overlaps between multiple points in the real world and an extensive and distinct large population social metaverse (As opposed to isolated virtual objects, data, 3D models or collaborative spaces of most augmented reality systems to date) constitute a new class of augmented reality interaction for social engagement characterized by multiple contacts and parallel existences which we call "Augmented Duality".

## 2. Real World/Metaverse Interactions

### 2.1 Spellbinder Camera Phone Interaction

Spellbinder is a server based applications for camera phones which embeds and releases digital content such as text, sounds, images and video from objects in the physical world. Content can also be overlayed on images of the world as in augmented reality. This is made possible by capturing images of objects or places which are then stored as targets. If the target is seen in a new image then the digital content is released even if the new image is from a different perspective or under different lighting. A user will take a picture of a target using a camera phone. The image is then sent to a server by MMS. The picture is striped out of the message and matched to others on the server using a point based matching algorithm. A response is then sent back to the phone as a text, mms or wap push (mobile internet). A recent application has been to hide "invisible" art on the facades of buildings [4]. The main effect is that Spellbinder makes it seem as though the real world and previously neutral objects such as posters, objects or facades of buildings are "activated" as reactive digital media. The physical world becomes a digital medium which can be hyperlinked to digital content. Previously hyperlinking to the physical world has been through "tags" such as barcodes and related technologies. Spellbinder's use of images means no physical tags are required in the world apriori. Also this opens up the possibility of user chosen hyperlinking in realtime. GPS systems only give position as opposed to what is being looked at.

The design team reflected on the use of metaverses as sites of social interaction. One conclusion was that there was little connection with the real world and remote users could not share their context of place. We therefore determined to extended the



**Figure 1:** An enclosure in Second Life for meetings. Images from mobile phones can trigger the walls to mimic a real place.

use of Spellbinder to make portals from the real world to the metaverse Second Life. Firstly it is possible to send camera phone images from a location in the real world and have them augment a specific position in Second Life. Secondly, it is also possible to link views of locations in Second Life to objects or places in the real world. If users take an image of the real location and send it to a server then an image is returned of the real location augmented with content from the metaverse. We have also used the matching of camera phone images to trigger the metaverse to change to mimic the real location. We have built a box enclosure in Second Life (figure 1) which avatars can enter and is similar to the CAVE immersive virtual environment. When a user in the real world takes an image of a target real world location and sends it to our server the server recognises the location and changes images on the walls of the enclosure in Second Life. Also content from Second Life can augment real world images on camera phones. So far we have used this system to provide context to meetings "in world". Avatars meet in the enclosure in Second Life. The participants decide what the real world context should be. The user in that location sends an image of their location by phone to the server and the walls are changed to mimic that location. The participants thus share a sense of location and context. Further images of any content can be uploaded from camera phones to a single wall as a focus for conversation.

### 2.2 Symmetric Large Screen Mixed Reality

The Spellbinder enclosure provided a compelling visual context and visual content. However, on reflection the limitations of a desktop virtual environment were apparent in users having to work through a PC. The design team thus envisioned a system whereby some users could participate without a keyboard PC. Thus a symmetric large screen mixed reality boundary was created between two overlapping rooms in the real world and Second Life using image processing and background removal. Avatars and real people can interact by looking through the large screen in their space and see themselves and their counterparts rendered in the same space. Both avatars and real people can choose to view an augmented reality (real with virtual augmentation) or augmented virtuality (virtual with real augmentation).

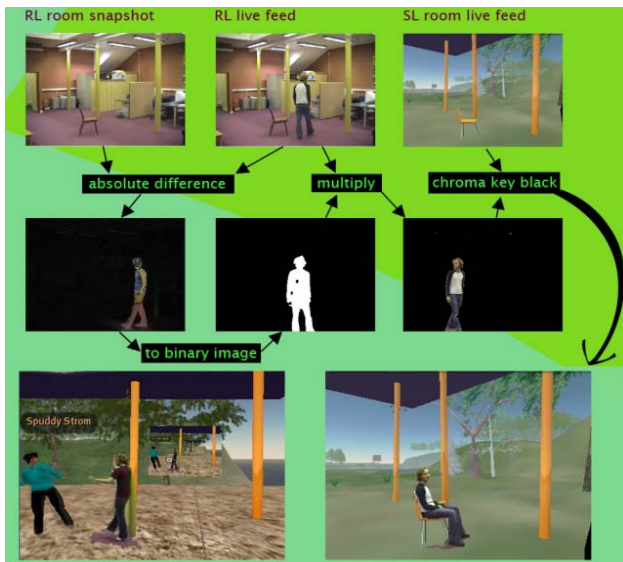


**Figure 2:** Large Screen mixed reality boundary in a real room. (a) Augmented virtuality space. (b) Augmented reality space.



**Figure 3:** View of overlay screen placed in Second Life

Figure 2 shows the large screen mixed reality boundary in a real space. Real people can gather in the room free from keyboards and the need for avatars. The system can show real or virtual backgrounds for augmented reality of augmented virtuality applications. With this interface the people can only see the avatar by peering through the screen boundary. Figure 3 shows the view in Second Life. Again with this interface the avatar cannot see the person directly in their own space but can see them augmented in a screen situated in the virtual world. Again this can have a virtual or real background. Figure 4 shows the image processing steps which create the mixed reality screen boundary views using background subtraction, masks and chroma keying. A live feed of activity in the real room is differenced with a background shot to create a binary alpha channel. This mask is multiplied with a Second Life feed to create an overlay. This content is then fed to the SL standard client as a quicktime stream. Another issue is that the camera showing the real room has to be carefully aligned with the virtual view in Second Life.



**Figure 4:** Image processing steps required to create the overlay

We exposed the system to small groups of collaborators both in the real room and as avatars in Second Life. There was agreement that the system was engaging and fun. Alignment of pillars and chairs in the two spaces made for visceral interactions. No usage context was given but curators from the National Museums of Scotland saw strong potential for such a system to replace spatial

and social context or for remote access, pre-visits and access to experts. During these trials it was accidentally discovered that due to the background removal process any object moved in the real world would instantly appear in the overlay which was an intuitive way of bringing new real objects into play. The main limitation was looking at the screen and people often looked around to try to see the avatars which were only visible on screen.

## 2.3 People as Video Sprites in Second Life

The design team reflected on the user feedback for the mixed reality boundary. A comment reflecting the principle weakness of all such systems is the absence of collaborators actually in each others spaces. This issue is most acute for remote users participating with the traditional PC interface. The design team thus determined to improved the presence of real people in Second Life by the use of 3D video sprites. This means that the avatar can see a real person as a video sprite which appears to be in the space rather than appearing as an overlay on a screen. Figure 5 shows a shot of a sprite of a person actually in the Second Life world.



**Figure 5:** Video sprite moving in 3D in Second Life

Figure 6 shows how the video sprite is automatically extracted from the live real room feed using similar techniques to those used to construct the mixed reality boundary display. The main difference is that the video sprite is given a position on a transparent object which is moved by http requests to a tracker using an overhead camera of the real room. In both systems we feed the video feeds out to the visual programming tool Max/MSP/Jitter which performs the necessary image processing steps and the outputs are then streamed back into Second Life. The video sprites are extracted using the same Max/MSP/Jitter tool and the sprite videos are attached to objects which are moved by http requests to a person tracker in Jitter. A script in an object in SL polls our server every second for the latest coordinates extracted by the motion tracker. The object then moves accordingly in the metaverse, there is a maximum refresh rate of 1/sec and the obelisk position is interpolated between each query. The surface of the object is set to be the video streamed from the sprite extraction software run in jitter. Streaming video in SL goes direct to the clients, it doesn't actually exist out there in the metaverse. Synchronisation of the video in the second life client with the movements of the object is thus necessary. We have not exposed users to this system because, although the tracking and sprite extraction are robust, the artificial limit on polling of position imposed by Second Life make fine movement synchronization difficult and have thus achieved only a single user and single avatar proof of concept.



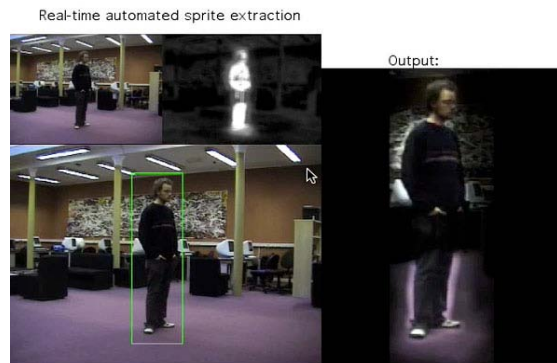


Figure 6: Automatic extraction of video sprites from real life

### 3. Discussion

#### 3.1 Augmented Duality – Augmenting the Real World with a Metaverse

The design team completed a series of three design interventions to overlay a metaverse with the real world using camera phones, image processing and augmented reality techniques. Following the approach of ‘Research by Design’ they then reflected on the wider context of the work. In particular they considered how these interventions now completed might provide new perspectives on the role of metaverses in social interaction. The main observation is that the sum of these interactions may point to an interesting emergent effect. We argue that augmentation of a metaverse creates a new form of augmented interaction. Classical augmented reality applications [2] use augmented content which is in a sense finite and local such as a virtual 3d object, text or architectural model. We believe multiple augmentation with a metaverse creates a new form of augmented interaction as the augmented context is an extensive social universe. An instructive comparison is to consider the emergence of social networking from conventional web based applications. Many of the practices and technologies underpinning social networking existed before such as webpages, instant messaging and email but the advent of mass social interaction created new phenomena. Also researchers in web technologies could only create small scale applications and could not see the emergent effects of mass social contact and user generated content. In a similar way we believe the advent of massive social online 3D metaverses will create similar emergent concepts of interaction and social practices. Researchers of augmented systems have only been able to create local finite augmented content. A metaverse is an extensive distinct social world which exists for many purposes other than augmentation. Metaverse is constructed from the words “meta” and “universe” A universe which is extensive, coherent and which can mimic or be entirely distinct from the real world universe. It is interesting to consider that Milgram and Kishino’s mixed reality continuum [5] is predicated on the former isolated application view of augmented reality applications. Milgram and Kishino suggest a taxonomy of systems consisting of a continuum with entirely real or virtual worlds at either end. In between is a range of mixed realities, including predominantly real content (Augmented Reality) and predominantly virtual (Augmented Virtuality). When we consider multiple metaverse augmentations they are not single points on the continuum as are isolated applications but a network of connections or “wormholes” along it. We term this new class of augmented interactions with metaverses “Augmented Duality” as

augmented metaverses support complex networks of simultaneous social existence in the real world and the metaverse.

#### 3.2 Limitations

There are at present a great many limitation to these systems. A key implementation issue is that we have created all of these interactions without altering the Second Life Client. We have instead used the video streaming and http request scripting capabilities of the objects on the Second Life servers to create these augmented effects. The use of the standard client was seen more of an interesting software challenge rather than a justified design decision as it limits choices and adds to complexity. Future work is likely to extend the client software. Only the Spellbinder phone component has been tested over an international distance. The realtime overlays have only been tested locally on a university network, there may be greater delays over large distances. There is a polling limit built into the scripted SL objects possibly as a security feature to prevent abuse. If this limit were removed then tracking would be much smoother. We have used the standard client as an interesting exercise but would recommend changing the client for control and speed. We also plan to change the client to control camera parameters. The main limitation for user interaction is the absence of the avatar in the real space and we aim to address this by projection or physical proxys.

### 4. Conclusion

We have overlapped a metaverse with the real world using a range of augmented and mixed reality techniques. We have used camera phones to create portals between the metaverse and real world and triggered the metaverse to mimic real locations through augmentation. We have created a mixed reality interaction boundary which can support a range of interactions. We have improved the presence of real people in the metaverse without avatars by using 3D video sprites which are positioned in the metaverse depending on the tracked position of the person in the real world.

Beyond this we suggest that many such interactions using a full, complex social metaverse as a subject for augmented interaction produces a new class of interaction which we call “Augmented Duality” which creates a rich network of parallel existences in the real world and metaverse. We believe this combination will create emergent interactions and exciting applications which we are only beginning to become aware of.

### 5. Acknowledgements

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